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MEMORANDUM

DATE **March 1, 2012**

TO **Town of Arlington**

FROM **Chen-Yuan Wang, Mark Abbott, and Efi Pagitsas, MPO Staff**

RE **FFY 2011 Safety and Operations Analyses at Selected Boston Region MPO Intersections: Massachusetts Avenue at Appleton Street and Appleton Place in Arlington**

INTRODUCTION

This memorandum summarizes safety and operations analyses and proposes improvement strategies for the intersection of Massachusetts Avenue at Appleton Street and Appleton Place in Arlington. It contains the following sections:

- Intersection Layout and Traffic Control
- Issues and Concerns
- Crash Data Analysis
- Intersection Capacity Analysis
- Preliminary Analysis of Traffic Signal Warrants
- Analysis of Traffic Signal Alternative
- Analysis of Other Improvement Alternatives
- Improvement Recommendations and Discussion

The memorandum also includes a collection of technical appendices that contain methods and data applied in the study and detailed reports of the intersection capacity analyses.

INTERSECTION LAYOUT AND TRAFFIC CONTROL

Massachusetts Avenue is a major thoroughfare in the Boston metropolitan area. It begins in the Boston neighborhood of Dorchester, goes through Boston Cambridge, Arlington, and Lexington, crosses Route 128, and enters Lincoln as North Great Road. The section in Arlington starts at Alewife Brook Parkway (Route 16), intersects Pleasant Street (Route 60) at Arlington center and Park Avenue at Arlington Heights, and continues west to Lexington.

This intersection is located on the east side of Arlington Heights about a mile northwest of Arlington center. Massachusetts Avenue (Mass. Ave.) in the vicinity of the intersection is a two-lane roadway classified as an urban principal arterial roadway, with a speed limit of 25 miles per hour (mph). Appleton Street is a two-lane roadway classified as an urban collector, with a speed limit of 30 mph.

Appleton Place is a two-lane local street where the speed limit is 25 mph. All the streets at the intersection are under the Town's jurisdiction.

Figure 1 shows the intersection layout and the area nearby. The intersection has an awkward layout. Appleton Street and Appleton Place, both located south of Mass. Ave., join the intersection at a skewed angle. The angle of the Appleton Street approach is especially sharp so that drivers approaching Mass. Ave. on Appleton Street have a very limited sight distance of Mass. Ave. eastbound traffic, and because the approach has a downward sloping grade, drivers tend to drive too fast. All the approaches at the intersection consist of one lane that is shared by all traffic movements. There are crosswalks on all the approaches except for Mass. Ave. west of the intersection. All the streets have sidewalks on both sides. On-street parking is allowed on both sides of Mass. Ave., on the south side of Appleton Street, and on the west side of Appleton Place.

The intersection is equipped with a traffic signal that is specifically used to stop traffic for pedestrian crossings. During normal operations, the signal flashes yellow on Mass. Ave., and it flashes red on Appleton Street and on Appleton Place. When any of the pedestrian buttons is pushed, an exclusive pedestrian phase is activated (when vehicular traffic at all of the approaches is stopped). During the pedestrian phase, the traffic signals change from flashing to solid, non-flashing yellow or red indications for about 3 seconds, and then all the signals change to steady red for about 25 seconds. During the steady red period, the pedestrian signals indicate flashing "Don't Walk" messages for about 7 seconds, a flashing "Walk" for about 11 seconds, and then again a flashing "Don't Walk" for about 7 seconds.

Located in a dense urbanized area, there are mixed land uses in the vicinity of the intersection. Both sides of Mass. Ave. have mainly commercial and office uses, mixed with multiple-family housing. To the south of Mass. Ave., the area known as Arlington Heights, the land use is mainly single- and multiple-family housing mixed with institutions such as schools and churches. On the north side of Mass. Ave., it is mainly multiple-family housing mixed with scattered single-family houses and office buildings. Near the intersection, there are a storefront containing shops and service offices and a few individual stores on the north side of Mass. Ave. One store has a driveway entering the intersection from its parking lot just north of the intersection. On the south side of Mass. Ave., there are multiple-family houses mixed with a few office uses, including a grief counseling center at the corner of Appleton Street. A Greek Orthodox church is located at the corner of Appleton Street and Appleton Place, with a large parking lot accessible from Appleton Place.

The only middle school in Arlington, Ottoson Middle School, is located about 500 feet south of the intersection. The school has about 1,000 students and its campus occupies the area bordered by Acton Street, Appleton Place, Quincy Street, and Benjamin Road. The main entrance is located at the bend of Acton Street (see Figure 1), but there are entrances at the other three corners of the campus that students can also use. The main drop-off route is from Acton Street (via Appleton Street), dropping off students at the main entrance, continuing on the one-way section of Acton Street, and leaving the school area via Appleton Place. Additionally, parents also can drop students off at the Benjamin Road entrance or at the entrance near the corner of Quincy Street and Appleton Place. All students are required to arrive by 7:55 and be seated by 8:05.

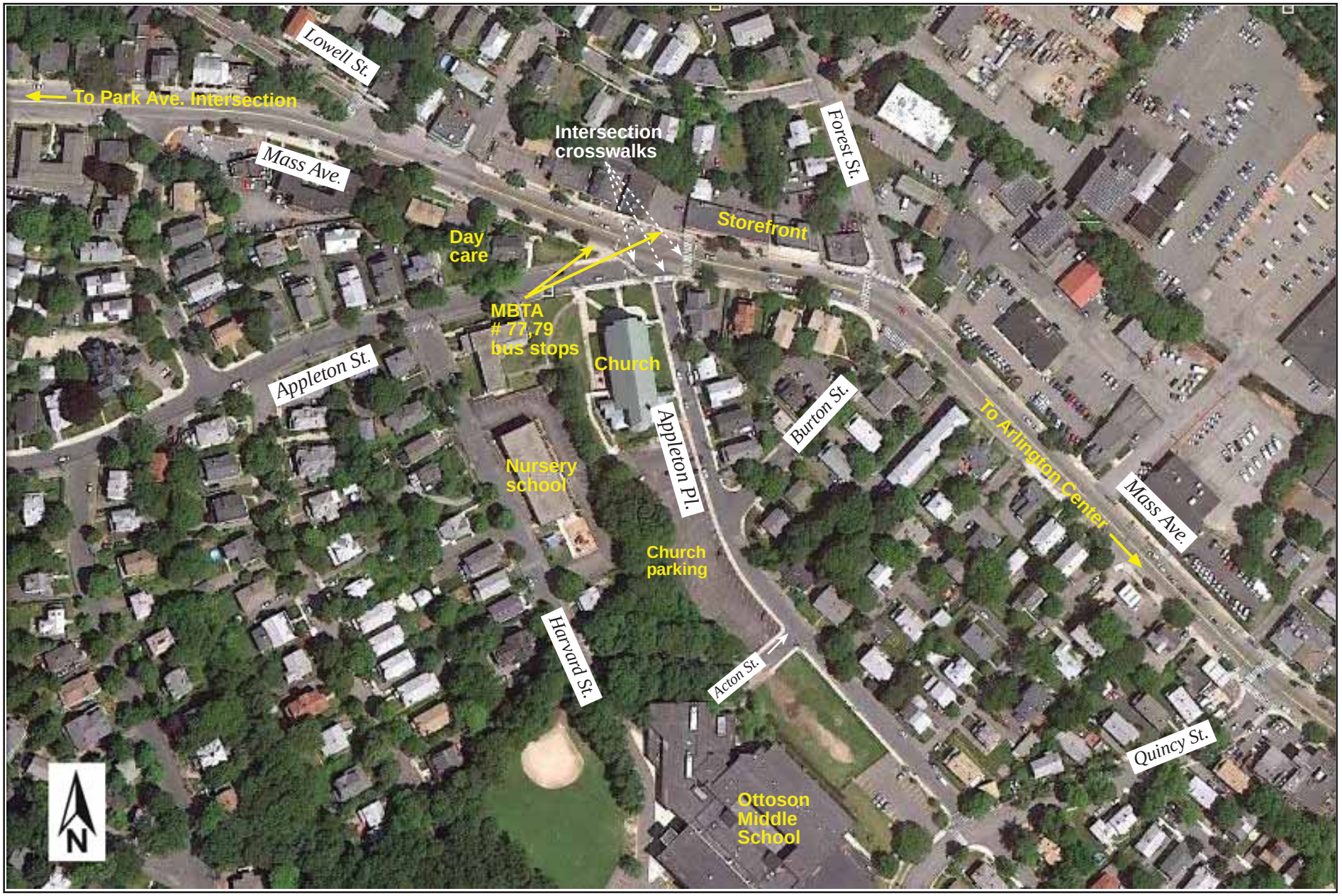

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FIGURE 1
Intersection Location and Surroundings
Mass Ave. at Appleton St./Appleton Palce, Arlington

Safety and Operations Analyses at Selected Intersections

Many of the middle school students (and their parents) use the intersection of Mass. Ave., Appleton Street, and Appleton Place to reach the school. They include students who take MBTA (Massachusetts Bay Transportation Authority) bus Routes 77 and 79 to this intersection and walk to the school, those who live on Mass. Ave. nearby and walk to school, and those who live to the east and north of the school and are dropped off by their parents. Currently there is a school crossing guard at the intersection to guide the students crossing Mass. Ave. during the school opening and releasing periods.

This intersection is a major stop for MBTA bus Routes 77 and 79. The two bus lines run along almost all of the section of Mass. Ave. in Arlington, from the Cambridge border to the bus stop in Arlington Heights for MBTA bus Route 77 (which is the end of that bus route).. The outbound stop is located at the north side of the intersection, just past the crosswalk on the Mass. Ave. westbound approach, and the inbound stop is located just before the stop line of the Mass. Ave. eastbound approach. Field observations indicate that there are nearly a hundred students taking the MBTA buses to the middle school every day.

Turning-movement counts recently collected by MPO staff indicate that about 10 to 20 bicyclists use the intersection during the morning and evening peak hours combined. The popular Minuteman Bikeway runs mostly parallel to Mass. Ave. in Arlington and crosses Mass. Ave. about 500 feet north of this intersection. Although none of the streets in this area have designated bike lanes, the travel lanes on Mass. Ave. are wide enough for shared bike use.

ISSUES AND CONCERNS

On May 25, 2011, staff met with members of the Arlington Transportation Advisory Committee and Town officers from the Planning and Community Development, Public Works, and Police departments to observe the morning traffic conditions and discuss the issues and concerns pertaining to this intersection. The major concern the Town has is the relatively high number of crashes at this intersection and students' safe access to Ottoson Middle School. A review of the most recent crash data indicates that the intersection has a high number of crashes and a crash rate higher than the average for unsignalized intersections in the MassDOT district 4 (see the next section for further analyses).

Currently there is a school crossing guard present to stop the traffic and direct pedestrian crossings at the intersection during the school opening and releasing periods. The intersection is wide and the guard has to be observant to cover the entire intersection. The crossing activity is especially intensive when students are dropped off from loaded MBTA buses.[1] Field observations indicate that a few, though not many, students crossed Mass. Ave. at locations other than the marked crosswalk.

Traffic is busy at the intersection during the AM and PM peak periods. Drivers from Appleton Street and Appleton Place usually have to endure extensive delays. In addition, the sharp angle of the Appleton Street approach limits the sight distance for drivers on that approach to see the traffic on the Mass. Ave. eastbound approach. At times, traffic on the Mass. Ave. westbound

[1] In the morning, students mostly come to the school on the outbound (westbound) buses. In the afternoon, most of them go home on the inbound (eastbound) buses.

approach backs up extensively, when the left-turn queue blocks the approach or when the exclusive pedestrian phase is actuated continuously. However, the backups usually dissipate in a few minutes.

The intersection can be confusing because some drivers may not be familiar with the flashing yellow and flashing red operations. In addition, multiple traffic signal heads (a total of 11) are scattered around the intersection and drivers may have a difficult time figuring out which one they should follow. It is especially confusing for drivers from the Appleton Street and Appleton Place approaches.

The issues and concerns for this intersection can be summarized as follows:

- High number of crashes and high crash rate
- Relatively high number of pedestrian and bicycle crashes
- Intensive student crossing activities during the middle school opening and releasing periods
- Short sight distance from the Appleton Street approach
- Confusing traffic signal settings and multiple signal heads, difficult for drivers to follow
- Traffic delays on the Appleton Street approach during peak hours

CRASH DATA ANALYSIS

Staff collected available crash data from the Massachusetts Department of Transportation (MassDOT) Registry of Motor Vehicles Division and Arlington Police Department (APD) for the most recent five years. The MassDOT data were available for 2006 to 2009, and detailed crash reports from APD were available for 2008 to 2010. Table 1 shows the statistics of the available crash data from the two sources combined. A summary of the crashes filed with APD is included in Appendix A.

On average, about five or more crashes occurred at the intersection each year.[2] More than one-third (36%) of the total crashes resulted in personal injuries and nearly two-thirds of the total crashes involved only property damage or were not reported. The crash types, not including data that were not reported, consist of about 56% rear-end collisions, 17% head-on collisions, 11% sideswipe collisions, 6% angle collisions, and 6% single-vehicle collisions.

The variety of the crash types is due partly to the irregular and complicated geometry of the intersection. A review of crash locations indicates that about half of the crashes occurred on Mass. Ave., about half of them occurred on Appleton Street, and no crashes occurred on Appleton Place. This distribution of crash locations and types is likely due to the sight distance deficiency on the Appleton Street approach.

[2] It should be noted that the 2010 crash data do not include data from the MassDOT crash database, which was still being updated at the time this report was prepared. Because of this, the number of crashes in 2010 is potentially greater than five.

TABLE 1
Summary of MassDOT and Arlington Police Department Crash Data (2006–10)

Statistics Period		2006	2007	2008	2009	2010	5-Year
Total Number of Crashes		5	8	5	5	5	28
Severity	Property Damage Only	2	4	5	2	3	16
	Personal Injury	3	3	0	2	2	10
	Fatality	0	0	0	0	0	0
	Not Reported	0	1	0	1	0	2
Collision Type	Angle	0	1	0	0	0	1
	Rear-end	2	1	1	2	4	10
	Sideswipe	0	1	0	1	0	2
	Head-on	1	0	1	1	0	3
	Single Vehicle	0	0	1	0	0	1
	Not Reported	2	5	2	0	1	10
Involved Pedestrian(s)		1	0	1	0	0	2
Involved Cyclist(s)		0	1	1	0	0	2
Occurred during Weekday Peak Periods*		1	3	4	0	1	9
Wet or Icy Pavement Conditions		1	0	1	2	1	5
Dark/Lighted Conditions		1	1	1	1	2	6

* Peak periods are defined as 7:00–10:00 AM and 3:30–6:30 PM.
Note: 2010 crashes are Arlington Police Department data only.

About one-third of the total crashes occurred during peak periods. About 20% of the total crashes occurred when the roadway pavement was wet or icy. In the past five years, there were two crashes that involved pedestrians and two crashes that involved bicyclists. This amounts to nearly one pedestrian or bicyclist crash each year. In the opinion of the staff, this rate is considered somewhat alarming for the safety of pedestrians and bicyclists at an intersection.

Crash rate is another effective tool for examining the relative safety of a particular location.[3] Based on the above crash data and the recently collected traffic volume data, the crash rate for this intersection is calculated as 0.98 (see Appendix B for the calculation). It is higher than the average rate for the unsignalized locations in MassDOT Highway Division District 4, which is estimated to be 0.59.[4]

INTERSECTION CAPACITY ANALYSIS

To examine the intersection's existing transportation conditions, MPO staff collected on May 4, 2011, vehicle and bicycle turning-movement counts and counts of pedestrian crossings at the

[3] Crash rates are estimated based on crash frequency (crashes per year) and vehicle exposure (traffic volumes or miles traveled). Crash rates are expressed as "crashes per million entering vehicles" for intersection locations and as "crashes per million miles traveled" for roadway segments.

[4] The average crash rates estimated by the MassDOT Highway Division are based on a database that contains intersection crash rates submitted to MassDOT as part of the review process for an Environmental Impact Report or Functional Design Report. The most recent average crash rates, which are updated on a nearly annual basis, are based on all entries in the database, not just those entries made within the past year. The average crash rate for MassDOT Highway Division District 4 was calculated on July 7, 2011.

intersection. The data were recorded in 15-minute intervals for the peak traffic periods in the morning, from 7:00 to 9:00, and in the evening, from 4:00 to 6:00. The collected data indicate that the peak traffic hour was from 7:30 to 8:30 in the morning and from 5:00 to 6:00 in the evening. Figure 2 summarizes the vehicle and bicycle turning movements and pedestrian crossings at the intersection in the two peak hours.

As Figure 2 shows, the intersection carried about 1,350 vehicles in the morning peak hour and nearly 1,500 vehicles in the evening peak hour. There were over 150 pedestrian crossings at the intersection in the morning peak hour. Over 100 pedestrians, most of them students coming from MBTA buses, crossed Mass. Ave.[5] Among them, about eight crossed on the western approach where no crosswalks exist. In the evening peak hour, the intersection had a total of nearly 40 pedestrian crossings. Most of them were made by the area's residents. There were about ten bicyclists using the intersection during the morning or evening peak hour (see Figure 2 for their turning movements).

Based on the turning movement counts, the intersection capacity was analyzed by using an intersection capacity analysis program, Synchro.[6] The intersection was modeled as an unsignalized intersection with a stop control on Appleton Street and Appleton Place. As the intersection has an irregular layout, it cannot be modeled as a regular two-way stop-controlled intersection in Synchro. Staff used SimTraffic to simulate the traffic conditions and evaluated the simulated delays based on the unsignalized intersection level-of-service criteria in the Highway Capacity Manual.[7]

Table 2 summarizes the level of service and average delay per vehicle estimated by the simulation. It shows that Mass. Ave. operated at the desirable level of service (LOS) A in both directions in the AM and PM peak hours, except for its westbound approach in the AM peak hour. It was estimated to operate at LOS F with an average delay of nearly a minute per vehicle.[8] Both of the stop-controlled approaches (Appleton Street and Appleton Place) were estimated to operate at an undesirable LOS F, with extensive delays of more than 3 minutes in the AM and PM peak hours, except for the Appleton Place approach in the PM peak hour, when it carried a low volume of traffic. Detailed simulation settings and results for both the AM and PM peak hour are included in Appendix C.

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[5] Presumably, there would be fewer students crossing Mass. Ave. during the school's releasing hour, roughly from 2:30 to 3:30, as some of them do not need to cross the street to wait for the buses.

[6] Synchro Version 7 and SimTraffic are developed and distributed by Trafficware Ltd. It can perform capacity analysis and traffic simulation (when combined with SimTraffic software) for an individual intersection or a series of intersections.

[7] Transportation Research Board, *Highway Capacity Manual 2000,* National Research Council, Washington D. C., 2000.

[8] The actual average delay for the westbound approach may be less than the estimated delay. When the left-turn queue is short, through traffic usually can go around it in the wide area of the intersection. This condition was not represented in the simulation.

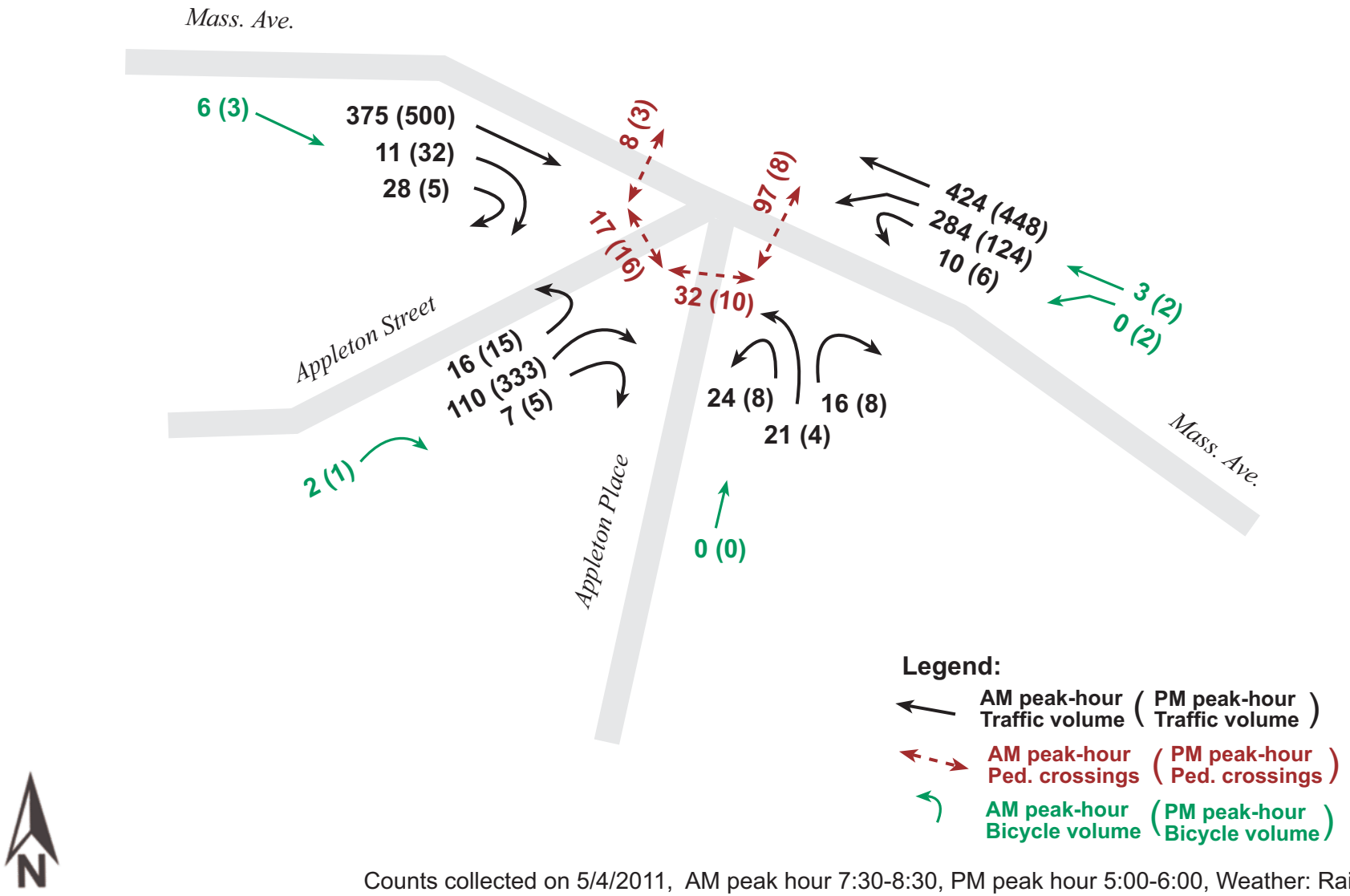

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FIGURE 2
Traffic/Bicycle Turning-Movement Counts and Pedestrian Crossings
Mass. Ave. at Appleton Street and Appleton Place, Arlington

Safety and Operations Analyses at Selected Intersections

TABLE 2
Intersection Capacity Analysis, Existing Conditions

Street name		Mass. Ave.						Appleton St.			Appleton Pl.		
Direction		Eastbound			Westbound			Northeast-bound			Northbound		
Turning movement		LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
AM peak hour	LOS	A			F			F			F		
	Delay (sec/veh)	2			58			>180			>180		
PM peak hour	LOS	A			A			F			E		
	Delay (sec/veh)	2			10			>180			46		

Note: Level of Service (LOS) criteria of A to F are based on the criteria for unsignalized intersections in the *Highway Capacity Manual 2000.*
Delay (seconds per vehicle) is estimated from SimTraffic simulation results.

PRELIMINARY ANALYSIS OF TRAFFIC SIGNAL WARRANTS

According to the 2009 *Manual for Uniform Traffic Control Devices* (MUTCD),[9] an engineering study of traffic conditions, pedestrian characteristics, and physical characteristics of the location should be performed to determine whether the installation of a traffic control signal is justified at a particular location. The investigation should include applicable factors contained in the following traffic signal warrants and other factors related to existing operations and safety at the study location:

1. Eight-Hour Vehicular Volume Warrant
2. Four-Hour Vehicular Volume Warrant
3. Peak-Hour Warrant
4. Pedestrian Volume Warrant
5. School Crossing Warrant
6. Coordinated Signal System Warrant
7. Crash Experience Warrant
8. Roadway Network Warrant
9. Intersection Near a Grade Crossing

A traffic control signal should not be installed unless one or more of the factors reflected in these warrants are met. Moreover, the satisfaction of a warrant or warrants in itself does not justify signal installation unless an engineering study indicates that the installation would improve the overall safety and/or operation of the intersection.

[9] Federal Highway Administration, U.S. Department of Transportation, Chapter 4C., "Traffic Control Signal Needs," 2009 Edition, December 2009.

In this study, we performed a preliminary analysis of the applicable traffic signal warrants based on available traffic data. The applicable factors for this intersection are contained in Warrants 1, 2, and 7. Warrant 3 is intended for unusual cases, such as office complexes, manufacturing plants, industrial complexes, or high-occupancy-vehicle facilities that attract or discharge large numbers of vehicles over a short time. The intersection is regarded as a stand-alone location, not a part of a coordinated traffic system. Therefore Warrants 3, 6, 8, and 9 were not tested.

The intersection currently does have a traffic signal, but it has only blinking red and yellow signals except for the exclusive pedestrian phase. A quick review of the traffic and pedestrian counts indicates that this intersection meets the requirements of Warrants 4 and 5 for a pedestrian signal .

To further examine if the intersection warrants a traffic signal for controlling traffic, staff reviewed the required traffic conditions of Warrants 1, 2, and 7. The examination was based on hourly volumes of an average weekday derived from three midweek days' 24-hour automatic traffic counts. The counts were collected by MassDOT's Highway Division in the week beginning May 23, 2011; the volumes were considered typical for the season or even slightly higher than average (see Appendix D for the detailed summary of hourly volumes from all the approaches at the intersection).

As Table 3 shows, the intersection's existing traffic conditions meet the requirements of Warrants 1 (Eight-Hour Vehicular Volume Warrant) and 2 (Four-Hour Vehicular Volume Warrant). Although traffic conditions also meet the requirements of Warrant 7, for the purposes of this analysis, that warrant is not considered to be satisfied because the 2010 crash data do not clearly indicate five or more correctable crashes.[10]

Staff concluded that this intersection qualifies for the installation of a traffic signal for controlling traffic, as its traffic conditions meet the requirements of Warrants 1 and 2. To justify the need for installation of a traffic signal, MassDOT usually prefers that Warrant 1, eight-hour vehicle volume, be met.

[10] The 2010 APD data indicate that there were four rear-end crashes and one unknown type of collision.

TABLE 3
Summary of Hourly Volumes and Warrant Fulfillment

Hourly Period Starting	Mass. Ave. (main street)		Appleton St. (minor street)		Sum of Main Street	Higher of minor street	Volumes above the minimum requirement		
	EB	WB	SB	NB			Warrant 1	Warrant 2	Warrant 7
6:00	191	242	49	3	433	49			
7:00	413	662	110	25	1075	110	X	X	X
8:00	427	749	142	21	1176	142	X	X	X
9:00	462	513	113	25	975	113	X	X	X
10:00	508	478	96	21	986	96	X		X
11:00	528	496	99	23	1024	99	X	X	X
12:00	501	500	121	16	1001	121	X	X	X
13:00	530	487	112	25	1017	112	X	X	X
14:00	532	525	138	26	1057	138	X	X	X
15:00	558	527	177	25	1085	177	X	X	X
16:00	500	492	227	30	992	227	X	X	X
17:00	522	540	370	28	1062	370	X	X	X
18:00	503	495	277	34	998	277	X	X	X
19:00	387	413	140	22	800	140	X		X

Note: The Warrant 1requirement is fulfilled. It requires that the traffic conditions (observed vehicular volumes higher than the specified minimum volumes) exist for each of any 8 hours of an average day. Condition B was applied in this case.
The Warrant 2 requirement is fulfilled. It requires that the traffic conditions (minimum volumes specified differently from Warrant 1) exist for each of any four hours of an average day.
The Warrant 7 (Crash Experience) requirement is fulfilled. It requires that traffic conditions of vehicular volumes higher than 80% of the volumes specified in Warrant 1 Condition B. However, the warrant is not satisfied, as the crash data do not meet the requirement of five or more correctable crashes in a recent 12-month period.

ANALYSIS OF TRAFFIC SIGNAL ALTERNATIVES

Alternative 1: Traffic Signal with Geometric Changes

The results of the traffic signal warrants analysis show that the required traffic conditions exist for Warrants 1 and 2 to be satisfied at this intersection. This section examines if and how a traffic signal control would work at this intersection.

Synchro tests of the installation of a traffic signal control indicate that under the existing layout the intersection would operate at an acceptable level of service (LOS) C, with an average delay of about half a minute per vehicle in both the AM and PM peak hours. Table 4 shows the LOS and average delay for each of the intersection approaches. Although the Appleton Street and Appleton Place approaches are estimated to endure an average delay of about one to one and half minutes in the AM peak hour, they are much improved from the stop-controlled operation. Moreover, the conflicts between the traffic on these two approaches and the traffic on Mass. Ave. would be reduced significantly with the traffic signal installation.

The signal was modeled as a fully actuated signal for an isolated intersection. All the approaches were modeled as one lane shared by all movements, except for the westbound approach.[11] It was designed to operate as a three-phase signal: (1) the Mass. Ave. eastbound and westbound approaches with permissive westbound left turns, (2) the Appleton Street approach, and (3) the Appleton Place approach, with an on-call exclusive pedestrian signal phase. The total cycle length of 120 seconds consists of 95 seconds of traffic phase and a pedestrian signal phase of 25 seconds (see Appendix E for details of the analysis of the signal alternative for both the AM and PM peak hours).

TABLE 4
Intersection Capacity Analysis
Traffic Signal Alternative under Existing Traffic Conditions

Street name		**Mass. Ave.**						**Appleton St.**			**Appleton Pl.**			**Overall**
Direction		**Eastbound**			**Westbound**			**Northeast-bound**			**Northbound**			
Turning movement		**LT**	**TH**	**RT**	**LT**	**TH**	**RT**	**LT**	**TH**	**RT**	**LT**	**TH**	**RT**	
AM peak hour	LOS	**B**			**B**			**E**			**F**			**C**
	Delay (sec/veh)	13			18			66			95			25
PM peak hour	LOS	**C**			**C**			**D**			**D**			**C**
	Delay (sec/veh)	21			22			49			40			26

In addition, a future-year scenario of 3% growth over a nearly 10-year planning horizon (2020) was tested for the traffic signal option. The growth assumption is based on a review of the traffic projections at the intersection from the recent Boston Region MPO transportation-planning model. The signalized intersection, without any major geometric design modifications, would still operate at an acceptable LOS C in both the AM and PM peak hours under the projected traffic conditions (see Appendix F for details of the analysis results).

The above analyses show that a traffic signal would operate acceptably at this intersection. The traffic signal would interrupt traffic on Mass. Ave. at intervals to permit traffic from Appleton Street or Appleton Place to proceed. Traffic operations on Appleton Street and Appleton Place would be significantly improved, with much reduced delays. Although delays on Mass. Ave. would increase somewhat, the overall intersection operations and safety would improve noticeably.

[11] A 25-feet storage space was added to the westbound approach in order to simulate the usual condition of the through movements going around one or two left-turn vehicles queuing at the intersection.

In addition, Alternative 1 would include (see Figure 3) the following geometric modifications:

- Realignment of Appleton Street to meet Mass. Ave. at a right-angle, to the degree feasible, considering right-of-way takings at the southwestern corner of the intersection at the intersection[12]
- Reconstruction of the area between Appleton Street and Appleton Place toward Mass. Ave to separate the two approaches to the degree feasible
- Construction of pedestrian bulb-outs at both ends of the crosswalk on the Mass. Ave. westbound approach
- Maintenance of the existing crosswalks and installation of a new one across the western approach of Mass. Ave.
- Installation of wheelchair ramps that meet ADA (American with Disabilities Act) and AAB (Massachusetts Architectural Access Board) standards at both ends of the crosswalks.

The realignment of Appleton Street would improve the sight distance for drivers on the Appleton Street and Mass. Ave. approaches. It would also help slow down the traffic to and from Appleton Street at the intersection.[13] More importantly, the realignment would create space for the expansion of the corner of Appleton Street and Appleton Place. The expansion would shorten the pedestrian crossing distance across Appleton Street and provide pedestrians with a generous staging area and better visibility of the traffic conditions on Mass. Ave. The installation of pedestrian bulb-outs on the Mass. Ave. westbound approach would also reduce the pedestrian crossing distance and provide better visibility for pedestrians of traffic on Mass. Ave. These modifications would significantly enhance the safety of all users at the intersection, especially pedestrians.

[12] The realignment would require setting back the stop bar of the Mass. Ave. eastbound approach by about 10 to 15 feet. The existing MBTA bus stop on the approach would also need to be set back accordingly.

[13] The acute angle of the existing alignment of Appleton Street allows traffic to speedily enter or exit the street from Mass. Ave. in a pattern similar to diverging from or merging to a ramp from a highway. A slower speed in the intersection would be safer for drivers and pedestrians.

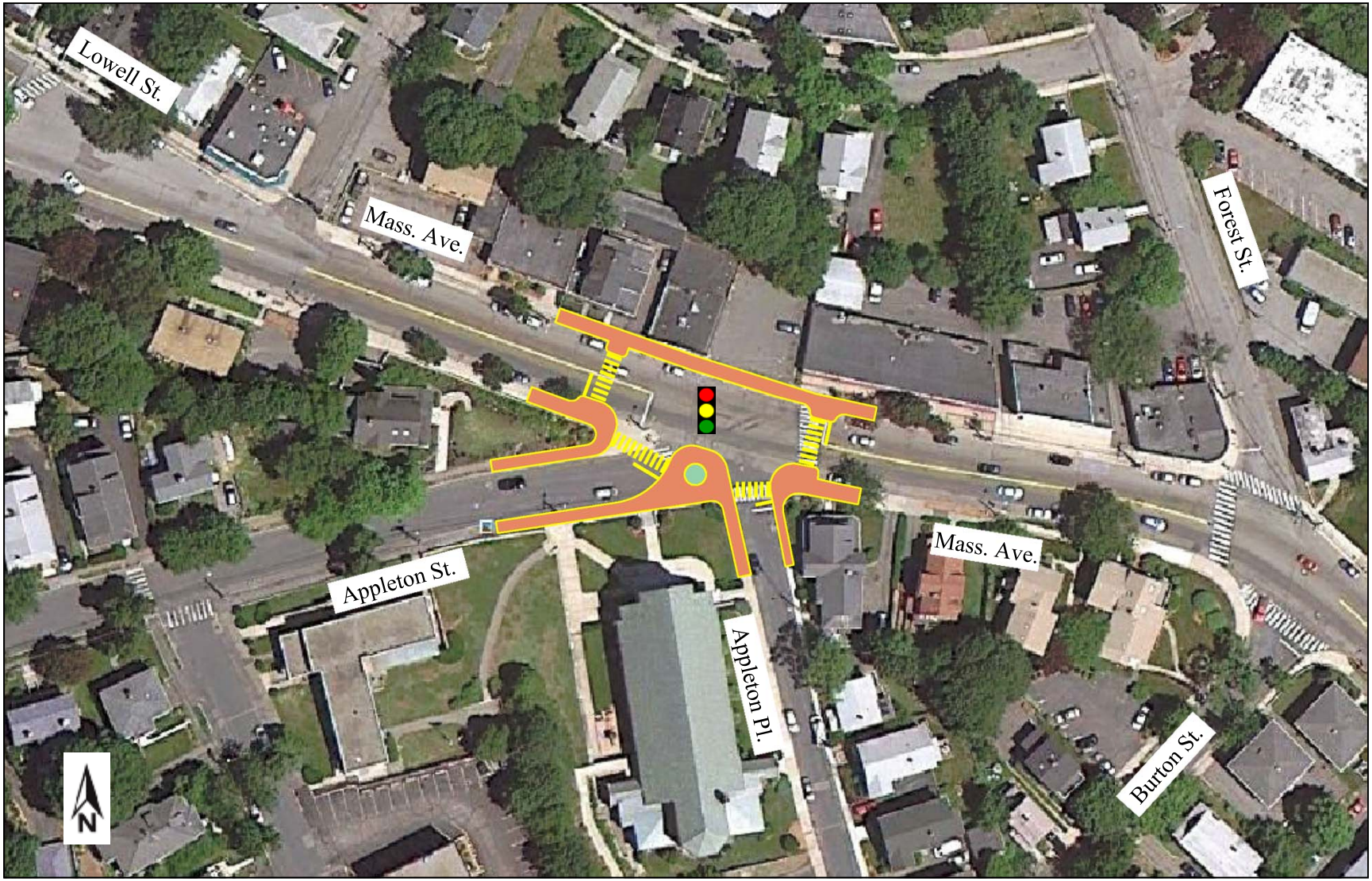

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FIGURE 3
Alternative 1: Traffic Signal with Geometric Changes
Mass. Ave. at Appleton Street and Appleton Place, Arlington

Safety and Operations Analyses at Selected Intersections

Alternative 2: Traffic Signal with Reduced Intersection Footprint

The aim of this alternative design would be to reduce the size of the intersection so that:

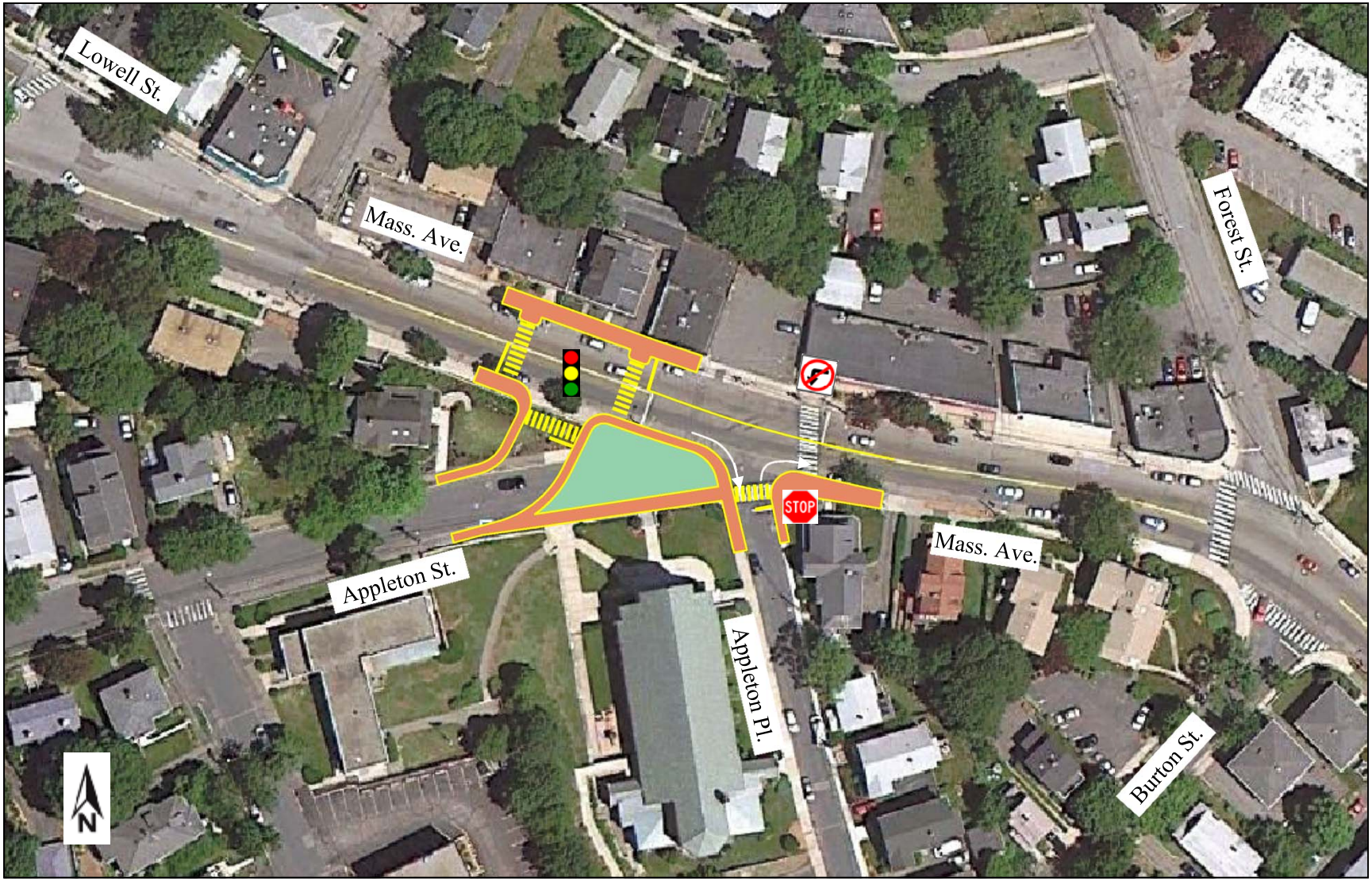
- Pedestrian crossing distances become shorter
- Sight distances from Appleton Street and Appleton Place are improved
- Traffic conflicts are minimized

As Figure 4 shows, the design elements of this alternative would include the following:

- Reconstruction of the Appleton Street approach to a right angle with Mass. Ave.
- Reconstruction of the Appleton Place approach so that it would angle to the left as it approaches Mass. Ave., creating a right-angle intersection with Mass, Ave. that is separate from the Appleton Street intersection with Mass. Ave., to the degree possible
- Designation of Appleton Place for right-in and right-out only traffic movements; right turns would be controlled by a stop sign
- Elimination of left turns to and from Appleton Place
- Moving the westbound Mass. Ave. stop line from its present location, which is closer to the Appleton Place approach than to the Appleton Street approach, to a location perpendicular to the reconstructed Appleton Street approach
- Installation of a new, fully actuated three-phase traffic signal, with two phases to control the Mass. Ave. intersection with Appleton Street and one exclusive phase for pedestrians
- Installation of crosswalks across Appleton Street, across both of the eastbound westbound approaches of Mass. Ave., and across Appleton Place
- Construction of bulb-outs to reduce the pedestrian crossing distances and for improved urban design

The benefits of this design would be a smaller intersection with improved sight distance from the Appleton Street minor approach. The Appleton Place approach would be taken out of the intersection and traffic flow into and out of Appleton Place would be under stop control. Bulb-outs and reconstructed pedestrian crossings would improve pedestrian safety and promote a "sense of place." As Appleton Place would not be subject to signal control, intersection operations and delays would be simplified and would improve, requiring only a three-phase signal design instead of the four phases required in Alternative 1. A simpler traffic signal design promotes shorter delays because of reduced all-red and amber intervals. In addition, this design presents opportunities for the incorporation of urban design elements and new landscaping.

Eliminating the left turns into and out of Appleton Place could be a concern to those who rely on access to and from Appleton Place by using left turns. Concerned parties may include residents along Appleton Place, parents of students being dropped off at the school, and church employees and members of the St. Athanasius Orthodox Church seeking access to the church's parking lot. A review of traffic volumes indicated that, in the peak hours, demand for left turns is low.



BOSTON REGION MPO

FIGURE 4
Alternative 2: Traffic Signal with Reduced Intersection Footprint
Mass. Ave. at Appleton Street and Appleton Place, Arlington

Safety and Operations Analyses at Selected Intersections

However, access is also available to and from other side streets connecting these activity locations to Mass. Ave. To mitigate this potential concern, careful consideration would have to be given to redirecting this demand for access to Mass. Ave. to other intersections to the east of this complicated location. For example, Quincy Street is a location that intersects at a right angle and has a simple geometry and smaller footprint that make them able to more easily accommodate the demand for left turns to access and egress points along Appleton Place.

ANALYSIS OF OTHER IMPROVEMENT ALTERNATIVES

During the development of improvement alternatives, staff also examined three additional design concepts to reduce traffic conflicts and to increase capacity at the intersection. All of them would have the potential of improving the intersection operations by reducing conflicting movements or by reducing entry volumes.to various degrees. They would also have associated impacts on existing traffic patterns in the area. These are:

- Converting the intersection into a modern roundabout
- Prohibiting left turns from Mass. Ave. to Appleton Street and Appleton Place during the AM and PM peak periods
- Making Appleton Place one-way between Mass. Ave. and just south of Burton Street

Although the intersection has not been fully analyzed, staff believe that it does not qualify for conversion to a roundabout design. This belief is largely based on three considerations:

- The volumes of left turns made at the intersection from all approaches are not balanced, and balanced numbers of left turns are a major criterion for the feasibility of a roundabout design.
- Roundabout conversion would require major land-takings at the intersection.
- The downward-sloping grade of Appleton Street as it approaches Mass. Ave. is of concern for a roundabout design.

Thus, staff considers this design concept of a roundabout to be infeasible at this location.

Prohibiting left turns from Mass. Ave. westbound would potentially divert the left-turning traffic downstream to the already congested Park Avenue intersection or upstream to other side streets from Mass. Ave. This would be a change from the present pattern, where parents turning left from Mass. Ave. to Appleton Street then proceed to Acton Street, their preferred route for dropping off students. Since the demand for left turns from Mass. Ave. to Appleton Street is rather high, and therefore this prohibition would major changes to existing traffic patterns, this concept will not be considered further.

Making Appleton Place a one-way street away from Mass. Ave. would help reduce the number of phases at the recommended traffic signal by diverting Appleton Place traffic exiting to Mass. Ave. at the Appleton Place approach to other side streets for access to Mass. Ave. Drivers could choose to use Quincy Street to either turn right onto Mass. Ave. or to turn left to go through Arlington Heights to reach Route 2. In addition, this concept would require right-in and right-out

treatments of the church parking lot. Note that the one-way Appleton Place concept could be implemented in conjunction with either a modified Alternative 1 or a modified Alternative 2.

IMPROVEMENT RECOMMENDATIONS AND DISCUSSION

The above safety and operations analyses indicate that the existing layout and stop-control operations are not effective for the existing and future traffic conditions and cause safety concerns at this intersection. To improve safety and operations at the intersection, this study reviewed two potential alternatives that include the installation of a traffic signal and various levels of geometric modifications to the intersection. Staff determined that a fully actuated traffic signal is warranted and necessary for controlling traffic and providing exclusive signal phases for pedestrian crossings.

In Alternative 1, the installation of a traffic signal was justified through warrant analyses. In addition, the capacity analyses of the signalized intersection under the existing layout indicate that Appleton Street and Appleton Place traffic operations would improve noticeably with reduced delays. The intersection would operate at an acceptable LOS C in both the AM and PM peak hours.

The signal would be expected to reduce traffic conflicts on Mass. Ave., Appleton Street, and Appleton Place and reduce the frequency and severity of crashes. It would still provide exclusive pedestrian phases and maintain the pedestrian safely at this intersection.

Alternative 2 includes the installation of a traffic signal, as in Alternative 1, and additional modifications to the intersection geometry that would reduce its footprint. A smaller footprint shortens pedestrian crossing distances and reduces potential traffic conflicts even more. In this design, the Appleton Place traffic pattern is turned into a “right-in, right-out” operation and is not controlled by the traffic signal. This alternative also presents opportunities for improved urban design, and increased numbers of sidewalks and pedestrian crossings.

In closing, staff believe that implementing Alternative 1 would be sufficient for addressing the concerns expressed by the Arlington Transportation Advisory Committee. If adopted, it would include the following elements:

- A fully actuated traffic signal system with pedestrian signal heads
- Audible and countdown pedestrian signals[14]
- Overhead signal indications supported by mast arms, clearly visible from all approaches[15]
- Pedestrian push buttons at all corners of the intersection

[14] The countdown pedestrian signals would be helpful at this intersection, especially when many pedestrians (students) are crossing the intersection at the same time. The countdowns would also serve as a reminder to the middle school students, who tend to be distracted by their fellow students, to cross the street quickly.

[15] Currently there are multiple signal heads (about 11 in total) supported by individual posts scattered around the intersection. The overhead signals supported by two or three mast arms would reduce drivers’ confusion caused by the current multiple signal locations.

It should be noted that, even with the existing stop-control operations with exclusive pedestrian signal phases, the proposed intersection layout modifications in Alternative 1 would improve the operations and safety of the intersection significantly. Meanwhile, the reduction in roadway surface and the increase of landscaped area for pedestrian activities would create a sense of "place" for this residential and commercial area in the Arlington Heights neighborhood.

Alternative 2 (see Figure 4) promotes the concept of "sense of place" and urban design even more than Alternative 1 by reducing the footprint of the intersection and creating a distance between the two side streets that meet Mass. Ave. in a skewed angle creating a complicated intersection with very wide pavement. This design has the potential to improve the operational efficiency and safety of this intersection. As explained above, it also stands to create concerns about minor traffic pattern changes, something to be reviewed with users.

At this preliminary planning stage, the total cost of the signal installation and the intersection reconstruction is roughly estimated to be $1,500,000 to $2,000,000, not including any potential land-taking costs. The lower limit in the range would apply to the implementation of Alternative 1 and the higher limit would apply to Alternative 2. The installation of a fully actuated traffic system alone, with the upgraded audible and countdown pedestrian signals, would cost about $400,000 to $500,000.

Currently all the roadways connected to the intersection are under the jurisdiction of the Town of Arlington. The implementation would require that the Town and MassDOT work closely together through the project implementation process (see Appendix H). The Town would have to gather public consensus on the project and prepare the Project Need Form (PNF) and Project Initiation Form (PIF) for initial discussions with MassDOT District 4 regarding project initiation.

In the meantime, staff recommend that the Town maintain the school crossing guard at this location. The guard is helpful in guiding and overseeing the extensive crossing activities at the intersection. Even after the proposed improvements have been implemented, a school crossing guard may still be needed at this location. Field observations indicate that the crossing activities can be very intensive at times, such as the arrival of a loaded bus, and the energetic middle school students can be easily distracted, especially when they are released from the school and are interacting with fellow students. In addition, the students should be advised to cross Mass. Ave. at the marked crosswalk areas at the intersection all the time.

CW/MA/cw/ep

APPENDIX A

Crash Data Synopsis (2008 to 2010)

Mass Ave. at Appleton Street/Appleton Place, Arlington

Arlington Police Department

MASS AVE @ APPLETON STREET/APPLETON PLACE CRASH DATA
01/01/2008 TO 12//31/2010

INCIDENT	DATE	TIME	CRASH TYPE	SYNOPSIS
8008412	05/01/2008	16:54 HRS	W/O INJURY	Minor Damage. Paper Exchange. No crash report filed. Possible road rage incident.
8025228	11/30/2008	17:21 HRS	W/O INJURY	Party walked into the driver's mirror of a vehicle traveling NE on Appleton Street. Party stated she was not injured and continued on her way. Reported by operator of the vehicle. No statement/ID from pedestrian.
9013369	07/03/2009	10:27 HRS	W/O INJURY	Veh 1, while waiting to make a left-turn onto Appleton Street from Mass Ave, was rear-ended by Veh 2.
9022704	11/14/2009	19:54 HRS	W/O INJURY	Minor. Paper Exchange. No report filed.
9025288	12/24/2009	15:15 HRS	W/INJURY	Veh 1 traveling EB on Mass Ave when Veh 2 traveling WB on Mass Ave made a left turn onto Appleton in front of Veh. 1. Airbags deployed in Veh 1. Two parties in Veh 1 transported to hospital with minor injuries.
10004867	03/10/2010	18:36 HRS	CRUISER CRASH	Police Cruiser stopped for red light EB on Mass at Appleton St. rear-ended by another vehicle. No injuries.

MASS AVE @ APPLETON STREET/APPLETON PLACE CRASH DATA
01/01/2008 TO 12//31/2010

INCIDENT	DATE	TIME	CRASH TYPE	SYNOPSIS
10007244	04/04/2010	18:57 HRS	HIT AND RUN	Vehicle traveling NE on Appleton St and slowing for red light rear-ended by unknown vehicle that fled the seen. Minor injuries reported but refused medical attention.
10009093	04/29/2010	18:39 HRS	W/O INJURY	Call received at station that party was involved in a collision with bicyclist that was not injured. Information exchanged between two parties. No crash report filed.
10012446	06/12/2010	17:29 HRS	W/O INJURY	Veh 1 NE on Appleton St stopped at flashing red rear-ended by Veh 2. No injuries reported. No tows.
10023797	11/17/2010	12:45 HRS	W/O INJURY	Veh 1 NE on Appleton St stopped at flashing red at Mass Ave rear-ended by Veh 2 as the operator moved forward a little for a better view of Mass Ave. Airbag deployment in Veh 2. No injuries reported. Veh 2 towed from the scene.
10027069	12/31/2010	12:02 HRS	W/INJURY	Minor. No Report filed.

APPENDIX B

Calculation of Crash Rate

Mass Ave. at Appleton Street/Appleton Place, Arlington

INTERSECTION CRASH RATE WORKSHEET

CITY/TOWN : Arlington COUNT DATE : 5/4/2011

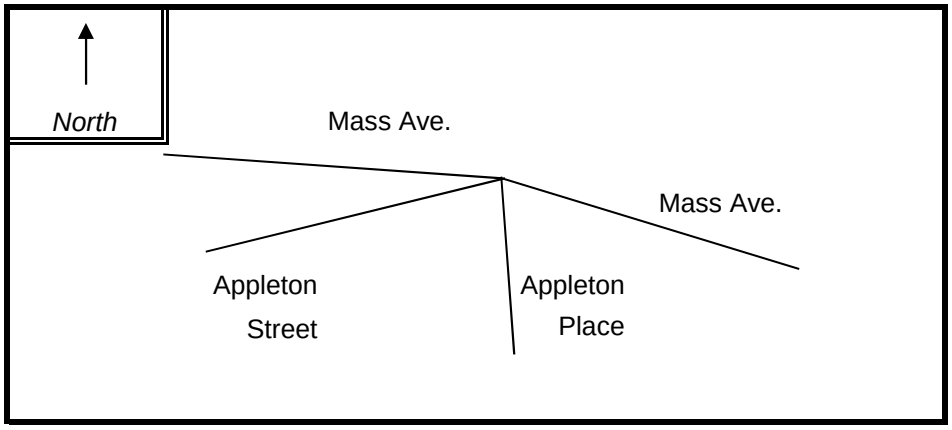
DISTRICT : 4 UNSIGNALIZED : X SIGNALIZED :

~ INTERSECTION DATA ~

MAJOR STREET : Mass Ave.

MINOR STREET(S) : Appleton Street/Appleton Place

INTERSECTION DIAGRAM (Label Approaches)



PEAK HOUR VOLUMES

APPROACH :	1	2	3	4	5	Total Peak Hourly Approach Volume
DIRECTION :	EB	WB	NEB	NB		
PEAK HOURLY VOLUMES (AM/**PM**) :	476	648	243	41		**1,407**

" K " FACTOR : **0.090** INTERSECTION ADT (**V**) = TOTAL DAILY APPROACH VOLUME : **15,633**

TOTAL # OF CRASHES : 28 # OF YEARS : 5 AVERAGE # OF CRASHES PER YEAR (**A**) : **5.60**

CRASH RATE CALCULATION : **0.98** RATE = $\frac{(A * 1{,}000{,}000)}{(V * 365)}$

Comments : MassDOT District 4 Average Rate = 0.59 (July 7, 2011)

Project Title & Date: Safety and Operations Analyses at Selected Intersections

APPENDIX C

AM/PM Peak-Hour Traffic Simulation Results

Existing Conditions

Mass Ave. at Appleton Street/Appleton Place, Arlington

Summary of All Intervals

Start Time	7:15
End Time	8:30
Total Time (min)	75
Time Recorded (min)	60
# of Intervals	2
# of Recorded Intvls	1
Vehs Entered	1274
Vehs Exited	1262
Starting Vehs	65
Ending Vehs	77
Denied Entry Before	0
Denied Entry After	27
Travel Distance (mi)	392
Travel Time (hr)	75.9
Total Delay (hr)	62.5
Total Stops	1168
Fuel Used (gal)	280.6

Interval #0 Information Seeding

Start Time	7:15
End Time	7:30
Total Time (min)	15

Volumes adjusted by Growth Factors.

No data recorded this interval.

Interval #1 Information Recording

Start Time	7:30
End Time	8:30
Total Time (min)	60

Volumes adjusted by Growth Factors.

Vehs Entered	1274
Vehs Exited	1262
Starting Vehs	65
Ending Vehs	77
Denied Entry Before	0
Denied Entry After	27
Travel Distance (mi)	392
Travel Time (hr)	75.9
Total Delay (hr)	62.5
Total Stops	1168
Fuel Used (gal)	280.6

4: Int Performance by approach

Approach	EB	WB	NB	NE	All
Total Delay (hr)	0.3	11.3	29.7	20.8	62.0
Delay / Veh (s)	2.3	58.1	3238.0	618.9	176.0
Stop Delay (hr)	0.0	8.8	29.8	20.9	59.6
St Del/Veh (s)	0.4	45.3	3250.1	622.7	169.1
Total Stops	12	957	52	147	1168
Stop/Veh	0.03	1.37	1.58	1.21	0.92
Travel Dist (mi)	72.9	96.4	3.0	14.7	187.0
Travel Time (hr)	2.4	14.4	29.8	21.4	68.0
Avg Speed (mph)	31	7	0	1	3
Fuel Used (gal)	21.6	53.5	69.2	52.4	196.7
Fuel Eff. (mpg)	3.4	1.8	0.0	0.3	1.0
HC Emissions (g)	4	10	0	5	19
CO Emissions (g)	1158	1976	345	928	4408
NOx Emissions (g)	13	22	1	6	41
Vehicles Entered	411	703	37	123	1274
Vehicles Exited	414	700	30	120	1264
Hourly Exit Rate	414	700	30	120	1264
Input Volume	414	718	61	133	1326
% of Volume	100	97	49	90	95
Denied Entry Before	0	0	0	0	0
Denied Entry After	0	13	14	0	27

Summary of All Intervals

Start Time	4:45
End Time	6:00
Total Time (min)	75
Time Recorded (min)	60
# of Intervals	2
# of Recorded Intvls	1
Vehs Entered	1391
Vehs Exited	1388
Starting Vehs	38
Ending Vehs	41
Denied Entry Before	0
Denied Entry After	53
Travel Distance (mi)	436
Travel Time (hr)	78.7
Total Delay (hr)	63.8
Total Stops	743
Fuel Used (gal)	289.0

Interval #0 Information Seeding

Start Time	4:45
End Time	5:00
Total Time (min)	15

Volumes adjusted by Growth Factors.

No data recorded this interval.

Interval #1 Information Recording

Start Time	5:00
End Time	6:00
Total Time (min)	60

Volumes adjusted by Growth Factors.

Vehs Entered	1391
Vehs Exited	1388
Starting Vehs	38
Ending Vehs	41
Denied Entry Before	0
Denied Entry After	53
Travel Distance (mi)	436
Travel Time (hr)	78.7
Total Delay (hr)	63.8
Total Stops	743
Fuel Used (gal)	289.0

4: Int Performance by approach

Approach	EB	WB	NB	NE	All
Total Delay (hr)	0.3	1.6	0.3	61.1	63.4
Delay / Veh (s)	2.3	10.1	45.8	815.1	163.9
Stop Delay (hr)	0.1	1.0	0.3	61.2	62.5
St Del/Veh (s)	0.4	6.2	44.9	815.8	161.7
Total Stops	2	238	23	480	743
Stop/Veh	0.00	0.42	1.00	1.78	0.53
Travel Dist (mi)	93.0	78.2	2.2	33.0	206.3
Travel Time (hr)	3.1	4.0	0.4	62.5	69.9
Avg Speed (mph)	31	20	6	1	6
Fuel Used (gal)	25.4	25.5	1.2	150.9	203.0
Fuel Eff. (mpg)	3.7	3.1	1.8	0.2	1.0
HC Emissions (g)	3	4	0	2	9
CO Emissions (g)	776	1059	17	1086	2938
NOx Emissions (g)	9	11	0	6	25
Vehicles Entered	526	570	23	272	1391
Vehicles Exited	529	571	23	269	1392
Hourly Exit Rate	529	571	23	269	1392
Input Volume	537	578	20	353	1488
% of Volume	99	99	115	76	94
Denied Entry Before	0	0	0	0	0
Denied Entry After	0	0	0	53	53

APPENDIX D

Average Daily Traffic (ADT) of the Study Area Roadways
May 23–26, 2011

Mass Ave. at Appleton Street/Appleton Place, Arlington

Mass Highway Department
WEEKLY SUMMARY FOR LANE 1
Starting: 5/23/2011

STA, 1EB

Site Reference: 110250000855
Site ID: 000000000103
Location: MASS AVE. WEST OF APPLETON ST.
Direction: EAST

File: 103.prn
City: ARLINGTON
County: VOL E.B.

TIME	MON 23	TUE 24	WED 25	THU 26	FRI	WKDAY AVG	SAT	SUN	WEEK AVG	TOTAL
01:00	30	23	29	31		28			28	113
02:00	19	7	12	20		14			14	58
03:00	8	6	11	15		10			10	40
04:00	10	9	14	9		10			10	42
05:00	25	35	28	30		29			29	118
06:00	63	51	63	81		64			64	258
07:00	174	190	190	211		191			191	765
08:00	400	415	423	416		413			413	1654
09:00	425	432	403	448		427			427	1708
10:00	421	574	438	417		462			462	1850
11:00	444	652	429			508			508	1525
12:00	503	611	472			528			528	1586
13:00	345	650	508			501			501	1503
14:00	495	577	518			530			530	1590
15:00	490	683	425			532			532	1598
16:00	489	682	504			558			558	1675
17:00	472	512	516			500			500	1500
18:00	515	527	525			522			522	1567
19:00	493	495	522			503			503	1510
20:00	357	392	412			387			387	1161
21:00	236	286	315			279			279	837
22:00	196	218	213			209			209	627
23:00	122	99	120			113			113	341
24:00	61	48	62			57			57	171
TOTALS	6793	8174	7152	1678	0	7375	0	0	7375	23797
% AVG WKDY	92.1	110.8	96.9	22.7						
% AVG WEEK	92.1	110.8	96.9	22.7						
AM Times	12:00	11:00	12:00	09:00		12:00			12:00	
AM Peaks	503	652	472	448		528			528	
PM Times	18:00	15:00	18:00			16:00			16:00	
PM Peaks	515	683	525			558			558	

W3

EB 7375
WB 6443
13818
.91 (.98)
12,300

Mass Highway Department
WEEKLY SUMMARY FOR LANE 1
Starting: 5/23/2011

Site Reference: 110250000579
Site ID: 000000000104
Location: MASS AVE. WEST OF APPLETON ST.
Direction: WEST

File: 104.prn
City: ARLINGTON
County: VOL W.B.

TIME	MON 23	TUE 24	WED 25	THU 26	FRI	WKDAY AVG	SAT	SUN	WEEK AVG	TOTAL
01:00	30	24	27	30		27			27	111
02:00	14	9	9	16		12			12	48
03:00	20	16	19	19		18			18	74
04:00	9	10	7	12		9			9	38
05:00	26	42	33	24		31			31	125
06:00	74	72	71	78		73			73	295
07:00	149	148	152	156		151			151	605
08:00	379	373	383	398		383			383	1533
09:00	495	499	487	493		493			493	1974
10:00	379	348	437	402		391			391	1566
11:00	393	375	421			396			396	1189
12:00	383	399	421			401			401	1203
13:00	431	470	461			454			454	1362
14:00	439	409	430			426			426	1278
15:00	427	478	411			438			438	1316
16:00	474	448	463			461			461	1385
17:00	425	435	413			424			424	1273
18:00	516	501	521			512			512	1538
19:00	396	420	402			406			406	1218
20:00	310	354	379			347			347	1043
21:00	209	305	298			270			270	812
22:00	148	177	164			163			163	489
23:00	99	103	121			107			107	323
24:00	44	46	62			50			50	152
TOTALS	6269	6461	6592	1628	0	6443	0	0	6443	20950
% AVG WKDY	97.2	100.2	102.3	25.2						
% AVG WEEK	97.2	100.2	102.3	25.2						
AM Times	09:00	09:00	09:00	09:00		09:00			09:00	
AM Peaks	495	499	487	493		493			493	
PM Times	18:00	18:00	18:00			18:00			18:00	
PM Peaks	516	501	521			512			512	

Mass Highway Department
WEEKLY SUMMARY FOR LANE 1
Starting: 9/12/2011

STA. 2 EB

Site Reference: 110250000408
Site ID: 000000020304
Location: MASS AVE. E. OF APPLETON PLACE
Direction: EAST

File: 20304.prn
City: ARLINGTON
County: DIR VOL E&W

TIME	MON 12	TUE 13	WED 14	THU 15	FRI	WKDAY AVG	SAT	SUN	WEEK AVG	TOTAL
01:00		35	28	29		30			30	92
02:00		10	13	12		11			11	35
03:00		6	11	9		8			8	26
04:00		15	13	17		15			15	45
05:00		26	33	34		31			31	93
06:00		65	66	73		68			68	204
07:00		237	234	231		234			234	702
08:00		526	500	566		530			530	1592
09:00		582	562	594		579			579	1738
10:00		529	535	537		533			533	1601
11:00		485	508			496			496	993
12:00	560	507	578			548			548	1645
13:00	559	614	570			581			581	1743
14:00	549	559	595			567			567	1703
15:00	618	623	606			615			615	1847
16:00	629	657	627			637			637	1913
17:00	718	709	752			726			726	2179
18:00	988	993	964			981			981	2945
19:00	764	823	840			809			809	2427
20:00	445	511	510			488			488	1466
21:00	263	322	361			315			315	946
22:00	199	227	215			213			213	641
23:00	117	105	120			114			114	342
24:00	60	85	62			69			69	207
TOTALS	6469	9251	9303	2102	0	9198	0	0	9198	27125
% AVG WKDY	70.3	100.5	101.1	22.8						
% AVG WEEK	70.3	100.5	101.1	22.8						
AM Times	12:00	09:00	12:00	09:00		09:00			09:00	
AM Peaks	560	582	578	594		579			579	
PM Times	18:00	18:00	18:00			18:00			18:00	
PM Peaks	988	993	964			981			981	

U3 EB 9198
WB 7932
COMB AWD 17130
FAC .93(.98)
COMB ADT 15,600

STA. 2 WB

Site Reference: 110250000408
Site ID: 000000020304
Location: MASS AVE. E. OF APPLETON PLACE
Direction: WEST

File: 20304.prn
City: ARLINGTON
County: DIR VOL E&W

TIME	MON 12	TUE 13	WED 14	THU 15	FRI	WKDAY AVG	SAT	SUN	WEEK AVG	TOTAL
01:00		21	33	27		27			27	81
02:00		13	23	16		17			17	52
03:00		13	20	16		16			16	49
04:00		9	10	12		10			10	31
05:00		33	36	27		32			32	96
06:00		79	95	90		88			88	264
07:00		257	236	235		242			242	728
08:00		688	628	671		662			662	1987
09:00		778	727	743		749			749	2248
10:00		496	514	529		513			513	1539
11:00		475	481			478			478	956
12:00	465	530	493			496			496	1488
13:00	504	524	472			500			500	1500
14:00	485	505	473			487			487	1463
15:00	514	566	495			525			525	1575
16:00	508	566	509			527			527	1583
17:00	515	471	491			492			492	1477
18:00	556	507	559			540			540	1622
19:00	473	499	513			495			495	1485
20:00	421	400	420			413			413	1241
21:00	256	268	310			278			278	834
22:00	147	217	183			182			182	547
23:00	108	100	118			108			108	326
24:00	49	60	56			55			55	165
TOTALS	5001	8075	7895	2366	0	7932	0	0	7932	23337
% AVG WKDY	63	101.8	99.5	29.8						
% AVG WEEK	63	101.8	99.5	29.8						
AM Times	12:00	09:00	09:00	09:00		09:00			09:00	
AM Peaks	465	778	727	743		749			749	
PM Times	18:00	15:00	18:00			18:00			18:00	
PM Peaks	556	566	559			540			540	

STA. 3 EB

Site Reference: 110250000511
Site ID: 000000030304
Location: APPLETON ST. WEST OF MASS AVE.
Direction: EAST

File: 30304.prn
City: ARLINGTON
County: DIR VOL E&W

TIME	MON 23	TUE 24	WED 25	THU 26	FRI	WKDAY AVG	SAT	SUN	WEEK AVG	TOTAL
01:00	10	16	16	11		13			13	53
02:00	7	1	10	2		5			5	20
03:00	6	2	3	3		3			3	14
04:00	2	2	2	2		2			2	8
05:00	2	5	4	7		4			4	18
06:00	16	12	11	10		12			12	49
07:00	41	53	58	45		49			49	197
08:00	111	122	82	125		110			110	440
09:00	132	141	143	152		142			142	568
10:00	98	130	105	119		113			113	452
11:00	89	101	98			96			96	288
12:00	92	99	107			99			99	298
13:00	106	125	132			121			121	363
14:00	114	110	114			112			112	338
15:00	134	153	128			138			138	415
16:00	170	172	191			177			177	533
17:00	223	245	214			227			227	682
18:00	341	372	399			370			370	1112
19:00	234	267	330			277			277	831
20:00	123	156	141			140			140	420
21:00	89	77	81			82			82	247
22:00	41	79	65			61			61	185
23:00	30	34	33			32			32	97
24:00	21	24	34			26			26	79
TOTALS	2232	2498	2501	476	0	2411	0	0	2411	7707
% AVG WKDY	92.5	103.6	103.7	19.7						
% AVG WEEK	92.5	103.6	103.7	19.7						
AM Times	09:00	09:00	09:00	09:00		09:00			09:00	
AM Peaks	132	141	143	152		142			142	
PM Times	18:00	18:00	18:00			18:00			18:00	
PM Peaks	341	372	399			370			370	

U6

EB 2411
WB 2158
4569
COMB AWD
FAC .91 (.99)
COMB ADT 4,100

STA. 3 WB

Site Reference: 110250000511
Site ID: 000000030304
Location: APPLETON ST. WEST OF MASS AVE.
Direction: WEST

File: 30304.prn
City: ARLINGTON
County: DIR VOL E&W

TIME	MON 23	TUE 24	WED 25	THU 26	FRI	WKDAY AVG	SAT	SUN	WEEK AVG	TOTAL
01:00	5	8	11	5		7			7	29
02:00	2	4	4	3		3			3	13
03:00	2	2	2	1		1			1	7
04:00	2	1	2	2		1			1	7
05:00	5	2	3	4		3			3	14
06:00	17	15	12	21		16			16	65
07:00	53	69	82	71		68			68	275
08:00	274	275	273	285		276			276	1107
09:00	250	272	255	263		260			260	1040
10:00	142	165	151	147		151			151	605
11:00	106	125	83			104			104	314
12:00	118	138	110			122			122	366
13:00	91	104	98			97			97	293
14:00	113	110	122			115			115	345
15:00	135	141	154			143			143	430
16:00	130	114	120			121			121	364
17:00	118	102	125			115			115	345
18:00	164	149	153			155			155	466
19:00	127	119	107			117			117	353
20:00	105	127	103			111			111	335
21:00	60	66	78			68			68	204
22:00	47	69	49			55			55	165
23:00	25	36	42			34			34	103
24:00	17	15	15			15			15	47
TOTALS	2108	2228	2154	802	0	2158	0	0	2158	7292
% AVG WKDY	97.6	103.2	99.8	37.1						
% AVG WEEK	97.6	103.2	99.8	37.1						
AM Times	08:00	08:00	08:00	08:00		08:00			08:00	
AM Peaks	274	275	273	285		276			276	
PM Times	18:00	18:00	15:00			18:00			18:00	
PM Peaks	164	149	154			155			155	

STA. 4 NB

Site Reference: 110250000658
Site ID: 000000040102
Location: APPLETON PL. SOUTH OF MASS AVE.
Direction: NORTH

File: 40102.prn
City: ARLINGTON
County: DIR VOL N&S

TIME	MON 23	TUE 24	WED 25	THU 26	FRI	WKDAY AVG	SAT	SUN	WEEK AVG	TOTAL
01:00	1	1	1	1		1			1	4
02:00	1	0	0	0		0			0	1
03:00	0	0	0	1		0			0	1
04:00	0	0	1	0		0			0	1
05:00	0	0	0	0		0			0	0
06:00	0	2	0	1		0			0	3
07:00	1	3	5	5		3			3	14
08:00	29	27	18	29		25			25	103
09:00	29	15	20	23		21			21	87
10:00	23	28	18	34		25			25	103
11:00	8	47	23	7		21			21	85
12:00	18	27	25			23			23	70
13:00	17	16	15			16			16	48
14:00	23	28	26			25			25	77
15:00	37	18	24			26			26	79
16:00	17	30	29			25			25	76
17:00	28	33	31			30			30	92
18:00	25	26	35			28			28	86
19:00	25	44	34			34			34	103
20:00	24	21	23			22			22	68
21:00	16	16	16			16			16	48
22:00	8	10	16			11			11	34
23:00	9	1	2			4			4	12
24:00	2	3	1			2			2	6
TOTALS	341	396	363	101	0	358	0	0	358	1201
% AVG WKDY	95.2	110.6	101.3	28.2						
% AVG WEEK	95.2	110.6	101.3	28.2						
AM Times	08:00	11:00	12:00	10:00		08:00			08:00	
AM Peaks	29	47	25	34		25			25	
PM Times	15:00	19:00	18:00			19:00			19:00	
PM Peaks	37	44	35			34			34	

U0

NB 358
SB 376
COMB AWD 734
FAC .91 (.99)
COMB ADT 660

Mass Highway Department
WEEKLY SUMMARY FOR LANE 2
Starting: 5/23/2011

STA. 4 SB

Site Reference: 110250000658
Site ID: 000000040102
Location: APPLETON PL. SOUTH OF MASS AVE.
Direction: SOUTH

File: 40102.prn
City: ARLINGTON
County: DIR VOL N&S

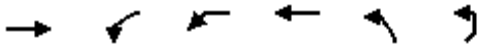
TIME	MON 23	TUE 24	WED 25	THU 26	FRI	WKDAY AVG	SAT	SUN	WEEK AVG	TOTAL
01:00	0	1	0	0		0			0	1
02:00	0	1	1	2		1			1	4
03:00	0	0	0	0		0			0	0
04:00	0	0	1	0		0			0	1
05:00	0	0	0	0		0			0	0
06:00	1	1	1	1		1			1	4
07:00	6	4	2	10		5			5	22
08:00	74	50	50	60		58			58	234
09:00	42	31	38	39		37			37	150
10:00	24	25	24	22		23			23	95
11:00	15	16	17	4		13			13	52
12:00	26	56	9			30			30	91
13:00	25	24	25			24			24	74
14:00	16	19	18			17			17	53
15:00	37	31	27			31			31	95
16:00	27	31	33			30			30	91
17:00	19	18	18			18			18	55
18:00	31	21	25			25			25	77
19:00	17	21	25			21			21	63
20:00	17	15	20			17			17	52
21:00	8	10	15			11			11	33
22:00	7	15	4			8			8	26
23:00	11	5	2			6			6	18
24:00	0	0	1			0			0	1
TOTALS	403	395	356	138	0	376	0	0	376	1292
% AVG WKDY	107.1	105	94.6	36.7						
% AVG WEEK	107.1	105	94.6	36.7						
AM Times	08:00	12:00	08:00	08:00		08:00			08:00	
AM Peaks	74	56	50	60		58			58	
PM Times	15:00	15:00	16:00			15:00			15:00	
PM Peaks	37	31	33			31			31	

APPENDIX E

AM/PM Peak-Hour Intersection Capacity Analysis

Traffic Signal Alternative under the existing Traffic conditions

Mass Ave. at Appleton Street/Appleton Place, Arlington

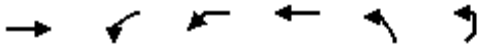


Lane Group	EBT	WBL2	WBL	WBT	NBL	NEL	ø13
Lane Configurations							
Volume (vph)	375	10	284	424	21	16	
Lane Group Flow (vph)	460	0	303	437	68	148	
Turn Type		Perm	Perm				
Protected Phases	4			8	2	6	13
Permitted Phases		8	8				
Detector Phase	4	8	8	8	2	6	
Switch Phase							
Minimum Initial (s)	4.0	4.0	4.0	4.0	3.0	3.0	4.0
Minimum Split (s)	20.0	20.0	20.0	20.0	7.0	10.0	25.0
Total Split (s)	63.0	63.0	63.0	63.0	9.0	23.0	25.0
Total Split (%)	52.5%	52.5%	52.5%	52.5%	7.5%	19.2%	21%
Yellow Time (s)	3.5	3.5	3.5	3.5	3.5	3.5	3.5
All-Red Time (s)	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Lost Time Adjust (s)	0.0	0.0	0.0	0.0	0.0	0.0	
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	
Lead/Lag							
Lead-Lag Optimize?							
Recall Mode	Min	Min	Min	Min	None	None	None
Act Effct Green (s)	59.5		59.5	59.5	5.0	18.6	
Actuated g/C Ratio	0.60		0.60	0.60	0.05	0.19	
v/c Ratio	0.43		0.69	0.40	0.80	0.77	
Control Delay	13.2		26.1	12.9	95.3	65.5	
Queue Delay	0.0		0.0	0.0	0.0	0.0	
Total Delay	13.2		26.1	12.9	95.3	65.5	
LOS	B		C	B	F	E	
Approach Delay	13.2			18.3	95.3	65.5	
Approach LOS	B			B	F	E	
Queue Length 50th (ft)	128		109	120	35	83	
Queue Length 95th (ft)	305		#356	286	#136	#231	
Internal Link Dist (ft)	904			683	469	614	
Turn Bay Length (ft)			25				
Base Capacity (vph)	1080		440	1099	85	198	
Starvation Cap Reductn	0		0	0	0	0	
Spillback Cap Reductn	0		0	0	0	0	
Storage Cap Reductn	0		0	0	0	0	
Reduced v/c Ratio	0.43		0.69	0.40	0.80	0.75	

Intersection Summary	
Cycle Length: 120	
Actuated Cycle Length: 98.6	
Natural Cycle: 110	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 0.80	
Intersection Signal Delay: 25.3	Intersection LOS: C
Intersection Capacity Utilization 78.3%	ICU Level of Service D
Analysis Period (min) 15	

\# 95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 4: Int



Lane Group	EBT	WBL2	WBL	WBT	NBL	NEL	ø13
Lane Configurations							
Volume (vph)	500	6	124	448	4	15	
Lane Group Flow (vph)	577	0	143	492	22	393	
Turn Type		Perm	Perm				
Protected Phases	4			8	2	6	13
Permitted Phases		8	8				
Detector Phase	4	8	8	8	2	6	
Switch Phase							
Minimum Initial (s)	4.0	4.0	4.0	4.0	1.0	3.0	4.0
Minimum Split (s)	20.0	20.0	20.0	20.0	6.0	10.0	25.0
Total Split (s)	56.0	56.0	56.0	56.0	7.0	32.0	25.0
Total Split (%)	46.7%	46.7%	46.7%	46.7%	5.8%	26.7%	21%
Yellow Time (s)	3.5	3.5	3.5	3.5	3.5	3.5	3.5
All-Red Time (s)	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Lost Time Adjust (s)	0.0	0.0	0.0	0.0	0.0	0.0	
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	
Lead/Lag							
Lead-Lag Optimize?							
Recall Mode	Min	Min	Min	Min	None	None	None
Act Effct Green (s)	42.5		42.5	42.5	3.1	29.4	
Actuated g/C Ratio	0.50		0.50	0.50	0.04	0.34	
v/c Ratio	0.63		0.64	0.54	0.32	0.75	
Control Delay	20.6		34.1	18.5	49.0	40.2	
Queue Delay	0.0		0.0	0.0	0.0	0.0	
Total Delay	20.6		34.1	18.5	49.0	40.2	
LOS	C		C	B	D	D	
Approach Delay	20.6			22.0	49.0	40.2	
Approach LOS	C			C	D	D	
Queue Length 50th (ft)	175		44	140	7	186	
Queue Length 95th (ft)	466		#196	377	#45	#514	
Internal Link Dist (ft)	904			683	469	614	
Turn Bay Length (ft)			25				
Base Capacity (vph)	1173		285	1165	68	526	
Starvation Cap Reductn	0		0	0	0	0	
Spillback Cap Reductn	0		0	0	0	0	
Storage Cap Reductn	0		0	0	0	0	
Reduced v/c Ratio	0.49		0.50	0.42	0.32	0.75	

Intersection Summary

Cycle Length: 120
Actuated Cycle Length: 85.6
Natural Cycle: 110
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.75
Intersection Signal Delay: 26.3 Intersection LOS: C
Intersection Capacity Utilization 77.6% ICU Level of Service D
Analysis Period (min) 15
95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

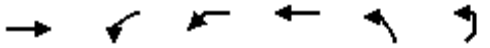
Splits and Phases: 7: Int

APPENDIX F

AM/PM Peak-Hour Intersection Capacity Analysis

Traffic Signal Alternative under 2020 Traffic conditions

Mass Ave. at Appleton Street/Appleton Place, Arlington

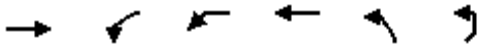


Lane Group	EBT	WBL2	WBL	WBT	NBL	NEL	ø13
Lane Configurations							
Volume (vph)	375	10	284	424	21	16	
Lane Group Flow (vph)	463	0	329	475	69	149	
Turn Type		Perm	Perm				
Protected Phases	4			8	2	6	13
Permitted Phases		8	8				
Detector Phase	4	8	8	8	2	6	
Switch Phase							
Minimum Initial (s)	4.0	4.0	4.0	4.0	3.0	3.0	4.0
Minimum Split (s)	20.0	20.0	20.0	20.0	7.0	10.0	25.0
Total Split (s)	63.0	63.0	63.0	63.0	9.0	23.0	25.0
Total Split (%)	52.5%	52.5%	52.5%	52.5%	7.5%	19.2%	21%
Yellow Time (s)	3.5	3.5	3.5	3.5	3.5	3.5	3.5
All-Red Time (s)	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Lost Time Adjust (s)	0.0	0.0	0.0	0.0	0.0	0.0	
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	
Lead/Lag							
Lead-Lag Optimize?							
Recall Mode	Min	Min	Min	Min	None	None	None
Act Effct Green (s)	62.2		62.2	62.2	5.0	18.7	
Actuated g/C Ratio	0.61		0.61	0.61	0.05	0.18	
v/c Ratio	0.43		0.74	0.43	0.82	0.79	
Control Delay	13.1		28.5	13.2	101.0	68.9	
Queue Delay	0.0		0.0	0.0	0.0	0.0	
Total Delay	13.1		28.5	13.2	101.0	68.9	
LOS	B		C	B	F	E	
Approach Delay	13.1			19.5	101.0	68.9	
Approach LOS	B			B	F	E	
Queue Length 50th (ft)	129		125	134	35	84	
Queue Length 95th (ft)	309		#400	318	#138	#233	
Internal Link Dist (ft)	904			683	469	614	
Turn Bay Length (ft)			25				
Base Capacity (vph)	1089		446	1109	84	192	
Starvation Cap Reductn	0		0	0	0	0	
Spillback Cap Reductn	0		0	0	0	0	
Storage Cap Reductn	0		0	0	0	0	
Reduced v/c Ratio	0.43		0.74	0.43	0.82	0.78	

Intersection Summary	
Cycle Length: 120	
Actuated Cycle Length: 101.5	
Natural Cycle: 120	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 0.82	
Intersection Signal Delay: 26.2	Intersection LOS: C
Intersection Capacity Utilization 79.7%	ICU Level of Service D
Analysis Period (min) 15	

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 4: Int



Lane Group	EBT	WBL2	WBL	WBT	NBL	NEL	ø13
Lane Configurations							
Volume (vph)	500	6	124	448	4	15	
Lane Group Flow (vph)	602	0	146	502	22	396	
Turn Type		Perm	Perm				
Protected Phases	4			8	2	6	13
Permitted Phases		8	8				
Detector Phase	4	8	8	8	2	6	
Switch Phase							
Minimum Initial (s)	4.0	4.0	4.0	4.0	1.0	3.0	4.0
Minimum Split (s)	20.0	20.0	20.0	20.0	6.0	10.0	25.0
Total Split (s)	56.0	56.0	56.0	56.0	7.0	32.0	25.0
Total Split (%)	46.7%	46.7%	46.7%	46.7%	5.8%	26.7%	21%
Yellow Time (s)	3.5	3.5	3.5	3.5	3.5	3.5	3.5
All-Red Time (s)	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Lost Time Adjust (s)	0.0	0.0	0.0	0.0	0.0	0.0	
Total Lost Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	
Lead/Lag							
Lead-Lag Optimize?							
Recall Mode	Min	Min	Min	Min	None	None	None
Act Effct Green (s)	52.7		52.7	52.7	3.0	28.3	
Actuated g/C Ratio	0.56		0.56	0.56	0.03	0.30	
v/c Ratio	0.59		0.54	0.50	0.37	0.87	
Control Delay	19.0		26.3	17.1	53.0	53.5	
Queue Delay	0.0		0.0	0.0	0.0	0.0	
Total Delay	19.0		26.3	17.1	53.0	53.5	
LOS	B		C	B	D	D	
Approach Delay	19.0			19.1	53.0	53.5	
Approach LOS	B			B	D	D	
Queue Length 50th (ft)	186		43	145	7	200	
Queue Length 95th (ft)	495		#186	387	#45	#519	
Internal Link Dist (ft)	904			683	469	614	
Turn Bay Length (ft)			25				
Base Capacity (vph)	1022		271	1014	60	457	
Starvation Cap Reductn	0		0	0	0	0	
Spillback Cap Reductn	0		0	0	0	0	
Storage Cap Reductn	0		0	0	0	0	
Reduced v/c Ratio	0.59		0.54	0.50	0.37	0.87	

Intersection Summary

Cycle Length: 120
Actuated Cycle Length: 94.9
Natural Cycle: 120
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.87
Intersection Signal Delay: 27.7 Intersection LOS: C
Intersection Capacity Utilization 79.3% ICU Level of Service D
Analysis Period (min) 15
95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 7: Int

APPENDIX G

MassDOT Project Implementation Process

MassDOT Project Implementation Process

The following description of the implementation process is based on Chapter 2 of the MassDOT Highway Division's *Project Development and Design Guide (2005)*. The text below borrows heavily from that document.

1 NEEDS IDENTIFICATION

For each of the locations at which an improvement is to be implemented, the MassDOT Highway Division leads an effort to define the problem, establishes project goals and objectives, and defines the scope of the planning needed for implementation. To that end, it has to complete a Project Need Form (PNF), which states in general terms the deficiencies or needs related to the transportation facility or location. The PNF documents the problems and explains why corrective action is needed. For this study, the information defining the need for the project will be drawn primarily, perhaps exclusively, from the present report. Also, at this point in the process, the MassDOT Highway Division meets with potential participants, such as the Boston Region Metropolitan Planning Organization (MPO) and community members, to allow for an informal review of the project.

The PNF is reviewed by the MassDOT Highway Division district office whose jurisdiction includes the location of the proposed project. The MassDOT Highway Division also sends the PNF to the MPO, for informational purposes. The outcome of this step determines whether the project requires further planning, whether it is already well supported by prior planning studies, and, therefore, whether it is ready to move forward into the design phase, or whether it should be dismissed from further consideration.

2 PLANNING

This phase will likely not be required for the implementation of the improvements proposed in this planning study, as this planning report should constitute the outcome of this step. However, in general, the purpose of this implementation step is for the project proponent to identify issues, impacts, and approvals that may need to be obtained, so that the subsequent design and permitting processes are understood.

The level of planning needed will vary widely, based on the complexity of the project. Typical tasks include: define the existing context, confirm project need, establish goals and objectives, initiate public outreach, define the project, collect data, develop and analyze alternatives, make recommendations, and provide documentation. Likely outcomes include consensus on the project definition to enable it to move forward into environmental documentation (if needed) and design, or a recommendation to delay the project or dismiss it from further consideration.

3 PROJECT INITIATION

At this point in the process, the proponent, the MassDOT Highway Division, fills out, for each improvement, a Project Initiation Form (PIF), which is reviewed by its Project Review Committee (PRC) and the MPO. The PRC is composed of the Chief Engineer, each District Highway Director, and representatives of the Project Management, Environmental, Planning, Right-of-Way, Traffic, and Bridge departments, and the Capital Expenditure Program Office (CEPO). The PIF documents the project type and description, summarizes the project planning process, identifies likely funding and project management responsibility, and defines a plan for interagency and public participation. First the PRC reviews and evaluates the proposed project based on MassDOT's statewide priorities and criteria. If the result is positive, the MassDOT Highway Division moves the project forward to the design phase, and to programming review by the MPO. The PRC may provide a Project Management Plan to define roles and responsibilities for subsequent steps. The MPO review includes project evaluation based on the MPO's regional priorities and criteria. The MPO may assign a project evaluation criteria score, a Transportation Improvement Program (TIP) year, a tentative project category, and a tentative funding category.

4 ENVIRONMENTAL, DESIGN, AND RIGHT-OF-WAY PROCESS

This step has four distinct but closely integrated elements: public outreach, environmental documentation and permitting (if required), design, and right-of-way acquisition (if required). The outcome of this step is a fully designed and permitted project ready for construction. However, a project does not have to be fully designed in order for the MPO to program it in the TIP.

5 PROGRAMMING

Programming, which typically begins during the design phase, can actually occur at any time during the process, from planning to design. In this step, which is distinct from project initiation, where the MPO receives preliminary information on the proposed project, the proponent requests that the MPO place the project in the region's TIP. The MPO considers the project in terms of regional needs, evaluation criteria, and compliance with the Long-Range Transportation Plan and decides whether to place it in the draft TIP for public review and then in the final TIP.

6 PROCUREMENT

Following project design and programming, the MassDOT Highway Division publishes a request for proposals. It then reviews the bids and awards the contract to the qualified bidder with the lowest bid.

7 CONSTRUCTION

After a construction contract is awarded, the MassDOT Highway Division and the contractor develop a public participation plan and a management plan for the construction process.

8 PROJECT ASSESSMENT

The purpose of this step is to receive constituents' comments on the project development process and the project's design elements. The MassDOT Highway Division can apply what is learned in this process to future projects.